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NOAA NPP Sounder Progress: EDR Development & Testing Progress and Development of AIRS and IASI Test Data

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Goals for Today's Presentation

- A very brief overview of the CrIMSS EDR Cal/Val plan (see Oct. 16, 2008 talk for more details)
  - Plan has been publicly released by IPO
- Summary of recent independent review of cal/val plan.
- Discuss development of proxy datasets
- Summary of recent SOAT meetings.

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Overview of CrIS/ATMS AVTP & AVMP Calibration and Validation Plan

- Main Objective – Validate the <u>NPOESS</u> Algorithm
- Achieve it by:
  - Incorporate lessons learned from Aqua, F16/SSMIS, TOVS, GOES, and METOP validation activities.
    - Concentrate on datasets proven valuable for global validation for AIRS & IASI (ECMWF, NCEP/GFS, RAOBs, etc)
  - Discussions with users to ensure our Cal/Val plan meets their needs.
  - Define the details of computing statistics from sparse *in-situ* measurements.
    - Details on how to "roll-up" regional statistics need to be worked out and <u>tested</u> prior to launch.
  - Characterize performance of EDRs in various ensembles of cases.
    - Test concepts pre-launch with simulated and proxy CrIS & ATMS datasets and compare results with heritage instruments and algorithms.

Overview of CrIS/ATMS AVTP & AVMP Calibration and Validation Plan

- Strategy
  - Build team of Subject Matter Experts (SMEs) from both customer and science communities to leverage heritage knowledge and tools as well as assure understanding of Customer Mission Success.
  - Leverage exisiting capabilities where-ever possible
    - operational heritage systems (ATOVS, MiRS, GOES)
    - Hyper-spectral AIRS/AMSU/HSB and IASI/AMSU/MHS processing and validation systems (NOAA, LaRC, MIT, SSEC)
    - routine AMSU, AIRS and IASI instrument monitoring and characterization,
    - and aircraft validation experience.

Who are our users?

- Heritage users
  - NWP centers are operational users of CrIS & ATMS SDRs
  - Operational, “IDPS-EDR”, algorithm is designed to satisfy needs of existing operational assets (HIRS, AMSU, MHS, SSMIS) AVTP and AVMP users.
    - Atmospheric stability for severe weather forecasting,
    - Flight plans, aerial refueling, high altitude reconnaissance, targeting, ballistic trajectories.
    - Initialize high resolution global air/ocean models. Greatest need is in bottom 1-2 km.
  - Cal/Val plan concentrates on validating these requirements.

Heritage Users	Hyper-spectral-era Users
NOAA	NOAA
FNMOC	NASA
AFWA	NCAR
NAVO	University

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Who are our users?

- Hyper-spectral-era (*i.e.,* AIRS and IASI) users
  - SDR should be capable of providing hyper-spectral-era products.
    - Trace gases, cloud products, cloud cleared radiances, OLR, etc.
    - Utilization of VIIRS data to improve sounding algorithms.
    - Averaging functions, error covariance matrices
  - NESDIS has an operational commitment to provide products for hyper-spectral-era users.
    - "NUCAPS-EDR" – NOAA-Unique CrIS/ATMS Processing System utilizes AIRS science team approach for AIRS and IASI for cloud cleared radiances, trace gases, OLR, etc.
  - Cal/Val plan utilizes hyper-spectral-era products to inter-compare with the NGAS products.
    - Motivation to incorporate lessons learned into operational algorithms.

Heritage Users	Hyper-spectral-era Users
NOAA	NOAA
FNMOC	NASA
AFWA	NCAR
NAVO	University

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Area of concern : IORD requirements are vague on a number of critical points

- We need to all agree how to compute EDR performance metrics.
  - NGAS specification will be used
  - Meeting NGAS specification implies we will meet IORD
- Determine if IORD requirements / NGAS specification has to be met on each layer (1-km) or on average of layers within a vertical cell?
  - For example, "2.6 K/1-km from surface to 700 mb" is computed on 1-km layers. Does each layer meet 2.6 K or does the average over the three layers used to derive the statistic?
- Traditional statistics for water allows weighting dry scenes lower than wet scenes to eliminate high percentage errors in polar scenes.
  - Do we follow AIRS science team approach?
    - If so, our statistic becomes ensemble dependent.
    - If not, must explicitly document methodology on all display of results.
- It is a "global" requirement
  - Scenes with precipitation > 2 mm/hr are excluded from meeting performance requirements.
  - Only choice is to use the coupled infrared retrieval or microwave-only retrieval for the statistics. Cannot ignore any scene ≤ 2 mm/hr or any part of a profile.

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CrIMSS EDR Requirements (Green are KPPs, Blue are P³I))

Parameter	IORD-II (Dec. 10, 2001)	NGAS SY15-0007 (Oct. 18, 2007)
AVMP Partly Cloudy, surface to 600 mb	**Greater of 20% or 0.2 g/kg**	**14.1% ocean, 15.8% land and ice**
AVMP Partly Cloudy, 600 to 300 mb	Greater of 35% or 0.1 g/kg	15% ocean, 20% land and ice
AVMP Partly Cloudy, 300 to 100 mb	Greater of 35% or 0.1 g/kg	0.05 g/kg ocean, 0.1 g/kg land and ice
AVMP Cloudy, surface to 600 mb	**Greater of 20% of 0.2 g/kg**	**15.8%**
AVMP Cloudy, 600 mb to 300 mb	Greater of 40% or 0.1 g/kg	20%
AVMP Cloudy, 300 mb to 100 mb	Greater of 40% or 0.1 g/kg	0.1 g/kg
AVTP Partly Cloudy, surface to 300 mb	**1.6 K/1-km layer**	**0.9 K/1-km ocean, 1.7 K/1-km land&ice**
AVTP Partly Cloudy, 300 to 30 mb	1.5 K/3-km layer	1.0 K/3-km ocean, 1.5 K/3-km land&ice
AVTP Partly Cloudy, 30 mb to 1 mb	1.5 K/5-km layer	1.5 K/3-km
AVTP Partly Cloudy, 1 mb to 0.5 mb	3.5 K/5-km layer	3.5 K/5-km
AVTP Cloudy , surface to 700 mb	**2.5 K/1-km layer**	**2.0 K/1-km**
AVTP Cloudy, 700 mb to 300 mb	1.5 K/1-km layer (clear=1.6)	1.5 K/1-km
AVTP Cloudy, 300 mb to 30 mb	1.5 K/3-km layer	1.5 K/3-km
AVTP Cloudy, 30 mb to 1 mb	1.5 K/5-km layer	1.5 K/5-km
AVTP Cloudy, 1 mb to 0.05 mb	3.5 K/5-km layer	3.5 K/5-km
Pressure Profile	4 mb threshold, 2 mb goal	3 mb (with precip and Psuif error exclusions)
CH4 (methane) column	1% precision, ±5% accuracy	n/a
CO (carbon monoxide) column	3% precision, ±5% accuracy	n/a

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Summary of AIRS & IASI Statistics Using AIRS Science Team Algorithm (Oct 2008 SOAT)

NOTE: These are the RSS{EDR + ECMWF} errors

AIRS Science "version 5" algorithm	IORD	AIRS	IASI
AVTP Partly Cloudy, surface to 300 mb	1.60	1.50	1.63
AVTP Partly Cloudy, 300 to 30 mb	1.50	1.13	1.60
AVTP Cloudy , surface to 700 mb	2.50	2.22	2.38
AVTP Cloudy, 700 mb to 300 mb	1.50	1.45	1.57
AVTP Cloudy, 300 mb to 30 mb	1.50	1.39	1.57
AVMP Partly Cloudy, surface to 600 mb	20%	29.1	22.1
AVMP Partly Cloudy, 600 to 300 mb	35%	40.8	28.3
AVMP Cloudy, surface to 600 mb	20%	26.9	24.4
AVMP Cloudy, 600 mb to 400 mb	40%	43.4	34.6

	AIRS		IASI	
	yield	Microwave-only	yield	Microwave-only
"Partly Cloudy"	53.3%	8.5%	55.0%	25.1%
"Cloudy"	44.4%	50.8%	37.9%	71.7%

Calibration and Validation EDR Activities

- Pre-Launch
- Early Orbit Check Out (launch +30 to +90 days)
- Intensive Cal/Val (stable SDR to L+24 months)
- Long Term Monitoring (stable SDR to end of mission)

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Hierarchy of Calibration and Validation Activities

Activity	Time-frame	Value
Use of proxy datasets	PL,EOC	Exercise EDR and fix issues.
Use of forecast & analysis fields	EOC	Early assessment of performance
Compare IDPS-EDRs to operational products from NUCAPS, AIRS & IASI	EOC,ICV,LTM	Early assessment of performance, diagnostic tools to find solutions.
Compare SDRs w/ AIRS and IASI via SNOs and double differences	ICV,LTM	Separate SDR/EDR issues at detailed level.
Operational PCA monitoring of radiances.	EOC,ICV,LTM	Instrument health. Identify and categorize interesting scenes.
RTG-SST and Dome-C AWS	LTM	Long-term stability of ICT
Operational RAOBs	ICV,LTM	Early assessment, long-term stability.
Dedicated RAOBs	ICV,LTM	Definitive assessment.
Intensive Field Campaigns	ICV,LTM	Definitive assessment.
Scientific Campaigns of Opportunity	Whenever	Detailed look at specific issues.

- PL = Pre-launch
- ICV = Intensive Cal/Val (stable SDR to L+24 m)
- EOC = Early Orbit Checkout (30-90 days)
- LTM = Long-term monitoring (to end of mission)

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Data Availability (via GRAVITE to all cal/val members)

Dataset	Status	Cost	Risk	Comments
NCEP-GFS	Have It	Very Low	Zero	Use for pre-launch proxy, post-launch quick checkout
ECMWF	Have It	Very Low	Low	May be cost to non-NOAA users
Aqua SDR & EDR	Have It	Very Low	Medium	Depends on health of Aqua
METOP SDR & EDR	Have It	Very Low	Low	Depends on heath of METOP-A/B
TOVS (& GOES), etc.	Have It	Very Low	Low	Depends on heath of NOAA-N,N’
Operational RAOBs	Have It	Very Low	Low	Early demonstration and long-term trends in AVTP,AVMP
Dedicated RAOBs (180/site/yr, 3 sites)	Budgeted	Medium	Medium	Low statistics, best demonstration of AVTP, AVMP, P(z)
Aircraft w/ NAST-M, NAST-I and SHIS	Need Support	High	High	NIST traceable, sub-pixel characterization.
Scientific campaigns of opportunity	Depends on schedules	Very Low	Low	Campaigns can encourage early scientific collaboration and focus on specific scientific applications.

Summary of Independent Review Comments on CrIMSS EDR Cal/Val

- Review team included Paul Menzel (chair), Pete Kealy, Jon Ranson, Paul Try, and Tom VonderHaar
  - All SDR and EDR cal/val plans were reviewed
  - Presentations by all cal/val leads were given June 30 to July 1, 2009
  - Report is in review and should be public soon
- Specific comments for CrIMSS EDR plan
  - A complete plan.
  - There are challenges in validating all the “cases” listed in the NPOESS IORD-II.
    - Various statistical domain tests and metrics will be available; which should be used realizing that none of them are likely conclusive insofar as EDR performance to the satisfaction of all users
  - Likelihood of some shortfalls in performance and the probable need for some additional funding for further algorithm research
    - Their planned cal/val dry run using existing AIRS and IASI data will facilitate early identification and more rapid solutions to such problems
  - Reprocessing of the Cal/Val data sets is planned and deemed necessary
  - The Sounder Operational Algorithm Team is providing the Subject Material Experts (SMEs) and the corporate memory
    - The coordination and activities between the IPO and NGAS CVPs is exceptionally well coordinated in this area.

Three basic types of proxy datasets are available.

- NOAA/STAR has developed simulated proxy datasets that are derived from the SARTA forward model for CrIS and MIT model for ATMS and use models for geophysical state (GFS + opaque clouds + simple emissivity).
  - Schedule is to have this running 1 year prior to launch, 24/7
  - Simulates NPP orbit with CrIS & ATMS spatial sampling strategy.
- AIRS/AMSU/HSB proxy datasets developed by Joel Susskind
  - Uses model to predict CrIS channels from AIRS
  - AMSU and HSB used directly.
- IASI/AMSU/MHS proxy datasets developed by Xu Liu (IASI), William Blackwell (ATMS), and Chris Barnet (datasets).
  - Direct transformation to CrIS channels.
  - AMSU and MHS transformed to ATMS polarization and sampling.
  - Provide ECMWF (if available), GFS, ATOVS retrievals, NOAA IASI retrievals, *in-situ* data (if available)

Issues for ATMS proxy generation from AMSU

- Spectrally, 11 ATMS channels are identical to AMSU, 5 have different polarization and 6 are unique.
- ATMS spatial sampling is 3 times finer in both along scan and along-track.
- ATMS scans farther (51.15^o vs 49.85^o)
- ATMS beam-patterns are different than AMSU

	AMSU/MHS			ATMS		
	Ch	GHz	Pol	Ch	GHz	Pol
AMSU-A	1	23.8	QV	1	23.8	QV
AMSU-A	2	31.399	QV	2	31.4	QV
AMSU-A	3	50.299	QV	3	50.3	QH
AMSU-A				4	51.76	QH
AMSU-A	4	52.8	QV	5	52.8	QH
AMSU-A	5	53.595 ± 0.115	QH	6	53.596 ± 0.115	QH
AMSU-A	6	54.4	QH	7	54.4	QH
AMSU-A	7	54.94	QV	8	54.94	QH
AMSU-A	8	55.5	QH	9	55.5	QH
AMSU-A	9	fo = 57.29	QH	10	fo = 57.29	QH
AMSU-A	10	fo ± 0.217	QH	11	fo±0.3222±0.217	QH
AMSU-A	11	fo±0.3222±0.048	QH	12	fo± 0.3222±0.048	QH
AMSU-A	12	fo ±0.3222±0.022	QH	13	fo±0.3222±0.022	QH
AMSU-A	13	fo± 0.3222±0.010	QH	14	fo±0.3222 ±0.010	QH
AMSU-A	14	fo±0.3222±0.0045	QH	15	fo± 0.3222±0.0045	QH
AMSU-A	15	89.0	QV			
MHS	16	89.0	QV	16	88.2	QV
MHS	17	157.0	QV	17	165.5	QH
MHS	18	183.31 ± 1	QH	18	183.31 ± 7	QH
MHS	19	183.31 ± 3	QH	19	183.31 ± 4.5	QH
MHS	20	191.31	QV	20	183.31 ± 3	QH
				21	183.31 ± 1.8	QH
				22	183.31 ± 1	QH

- Exact match to AMSU/MHS
- Only Polarization different
- Unique Passband
- Unique Passband, and Pol. different from closest AMSU/MHS channels

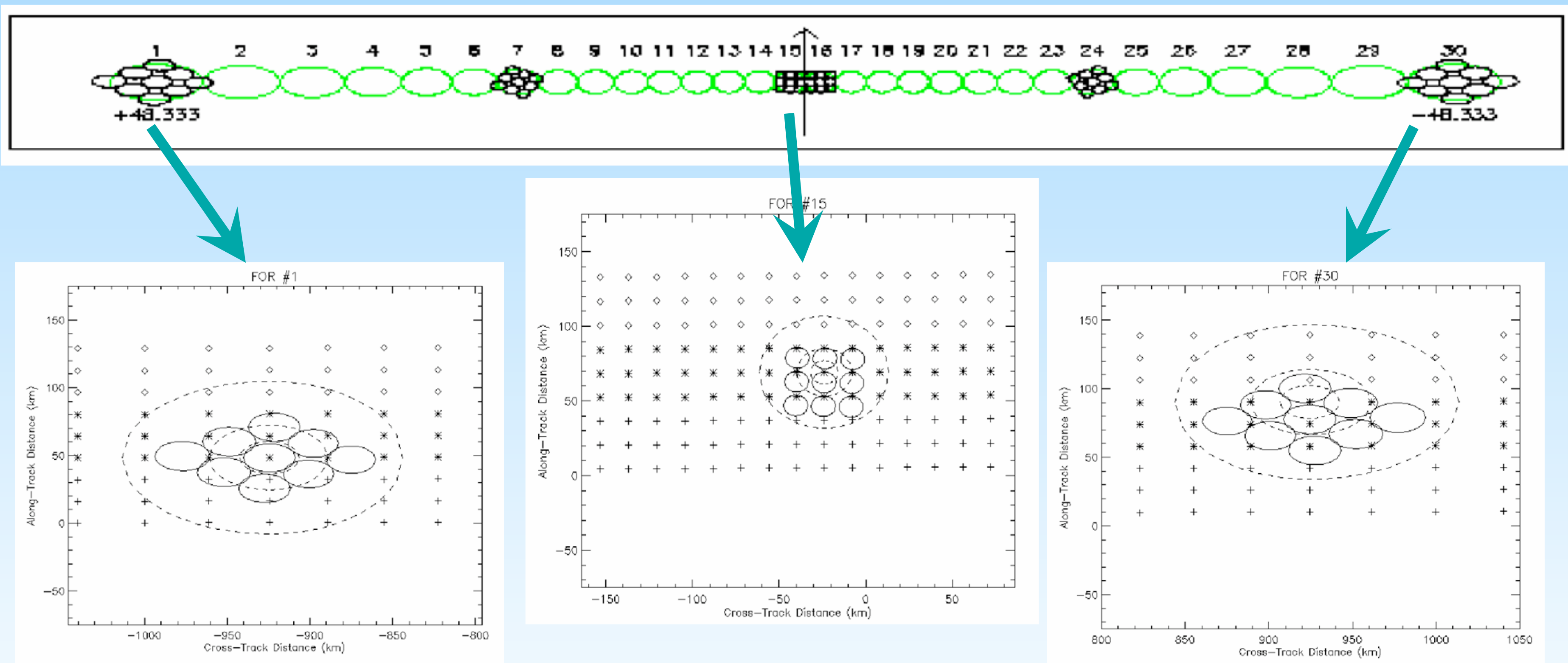
QV = Quasi-vertical; polarization vector is parallel to the scan plane at nadir

QH = Quasi-horizontal; polarization vector is perpendicular to the scan plane at nadir

Based on: Thomas Kleespies, "Rel. Info. Content of the ATMS and AMSU/MHS," IEEE Trans. Geosci. And Remote Sensing, Vol. 45, No. 7 July 2007

Co-location of CrIS & ATMS

NOTE: CrIS FOV's rotate w.r.t. to sub-sampled ATMS FOV's.



From pg. 260-266 of CrIS EDR ATBD (P1196-TR-I-4-0-ATBD-01-04, Feb. 8, 2007)

Proxy Data Generation from AIRS/AMSU-A/HSB and IASI/AMSU-A/MHS

Instrument	AIRS/AMSU-A/HSB	IASI/AMSU-A/MHS
Orbit	1:30 PM/AM Altitude 705 km	9:30AM/PM Altitude 833 km (~NPP)
FOVs	3 x 3 (non-rotating)	2 x 2 (non-rotating)
Method Used	Model/Regression for Proxy Data Generation $\hat{R}_{i,k}^{CrIS}(0) - \overline{\hat{R}_{i}^{CrIS}(0)} = \sum_{j} M_{i,j}\left(R_{j,k}^{AIRS}(0) - \overline{R_{j}^{AIRS}(0)}\right)$	Direct Transformation of Radiances From IASI Radiances $R_{u}^{CrIS} = \frac{1}{N}\sum_{k=0}^{N-1}\frac{a(k)}{g(k)}\left(\sum_{j=0}^{M-1} R_{j}^{IASI} e^{2\pi jk/M}\right)e^{-2\pi iu/N}$
Data Period	Sep 2002-Feb. 2003 with HSB. After Feb. 2003 but with loss of 183 GHz HSB channels.	July 2007 to present
Channel noise	A/B noise differences, popping channels, model error in gaps	IASI SW band has high noise, but spectral noise has same character.
Cloud Clearing	9 independent FOVs	4 independent FOVs

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Proxy datasets in development

Proxy Dataset	Timeframe	Fundamental Purpose
SARTA(GFS) with simple cloud and surface models	Granules, 24/7, all scenes	Test downstream dataflow and formats.
AIRS/AMSU/HSB	Granules for Focus days	EDR performance evaluation
IASI/AMSU/MHS	Granules for Focus days (possibly 24/7)	EDR performance during EOC and LTM phase
IASI/AMSU/MHS	RAOB matchup with 3 ARM sites, ~ 100/site/yr	EDR performance during ICV phase
IASI/AMSU/MHS	Granules for AEROSE campaign (Jul-Aug 2009, mid-Atlantic) and the START08 (May-Jul 2008)	EDR performance during ICV phase
IASI/AMSU/MHS	RAOB matchup	EDR Performance during LTM phase

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Highlights from recent SOAT meetings. (May 20-21, 2009 and Sep. 9-11, 2009)

- Pre-flight measurements indicate that CrIS is a high quality, well calibrated instrument.
  - Results and discussions demonstrated that many of the calibration concerns have been solved and that, where it matters, CrIS is meeting or exceeding specification.
  - CrIS is potentially a climate quality instrument with two caveats:
    - 1) that the SDR algorithm incorporate the most up to date parameters and methodologies
    - 2) additional testing be performed for future flight models.
- There has been an evolution in the ability to inter-compare satellite instruments and models for our calibration and validation efforts.
  - Evaluation of SNO’s, double differencing and climate products
  - NWP community (ECMWF and UKMet) is ready to evaluate NPP SDRs
  - In-situ validation site capabilities (ARM, Beltsville) are available.
  - Coordination of these activities will be a major focus in upcoming SOAT meetings.

Highlights from recent SOAT meeting (cont.)

- ATMS needs more testing for NPOESS C1 instrument.
  - side-lobe characterization (which is a major error component of the EDRs for difficult scenes), polarization, non-linearity corrections.
  - Additional testing is recommended by SOAT
- Discussions with the NASA atmosphere and sounding PEATE and had a number of discussions how we would organize communication between the Cal/Val team, SOAT, NGAS, PEATEs, and the IPO.
- Use of proxy data and the GRAVITE environment plays a central role in this communication.
  - Demonstration of GRAVITE at Sep. SOAT in Logan Utah.
- SOAT talks, released by authors, are available at
  - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/SOAT

BACKUP SLIDES

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NOAA/NESDIS Cal/Val Team Members

Team Member	Funding Source	Activity
Chris Barnet	IPO/Cal-Val	Cal/Val coordination. Define performance metrics, EDR algorithm issues. Scientific field campaigns of opportunity (START,HIPPO,AEROSE). Member of GCOS/WG-ARO for GRUAN.
Changyong Cao	IPO/Instrument Systems	Development of an integrated instrument Cal/Val system for NPP/NPOESS (*e.g.,* SNO AIRS/IASI/CrIS). Coordination with GSICS, CEOS-Cal/Val working group (WGCV).
Mitch Goldberg	IPO/Cal-Val	PCA analysis of radiance, quick look regression products. Coordination w/ GSICS.
	NESDIS/PSDI	NOAA Unique CrIS/ATMS Product System (NUCAPS)
		IASI Product System
Anthony Reale	IPO/Instrument Systems	NOAA PROduct Validation System (NPROVS) – CrIMSS/IASI/AIRS/ATOVS/RAOB matchups
Fuzhong Weng & Sid Boukabara	NESDIS/PSDI	Microwave Integrated Retrieval System (MIRS) and activities related to ATMS

Non-NOAA Cal/Val Team Members

Team Member	Organization	Responsibilities
Gail Bingham	USU/SDL	SDR Cal/Val lead, NGAS SDR code f/ Cal/Val team
Bill Blackwell	MIT	ATMS SDR/EDR issues. ATMS proxy datasets. NAST-M preparations and intensive campaign support.
John Derber, Paul Van Delst	JCSDA/NCEP	Global characterization of ATMS & CrIS biases w.r.t. NCEP analysis ATMS & CrIS SDR/EDR issues.
Allan Larar	NASA/LaRC	NAST-I preparations and intensive campaign support.
Xu Liu	NASA/LaRC	EDR algorithm issues, IASI proxy dataset
Hank Revercomb, Dave Tobin	U.Wisc	SDR issues (non-Gaussian noise), Scanning HIS preparation and intensive campaigns. ARM best estimate state analysis.
Joel Susskind	NASA/GSFC	AIRS proxy datasets.
Larrabee Strow	UMBC	SDR issues, radiative transfer issues, pre-flight instrument Cal/Val issues, OSS validation.

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Externally funded members of the Cal/Val team.

Participants	Organization	Planned Activities
Steven Beck	The Aerospace Corporation	Characterization of ATMS & CrIS biases w.r.t. RAOB, LIDAR.
Stephen English	UKMET	Global characterization of ATMS & CrIS biases w.r.t. UKMET analysis
William Bell	ECMWF	Global characterization of ATMS & CrIS biases w.r.t. ECMWF analysis
Steve Friedman, George Aumann	NASA/JPL	Global characterization of ATMS & CrIS. NPP sounder PEATE coordination.
Ben Ruston	NRL	Global characterization of ATMS & CrIS w.r.t. NOGAPS/NAVDAS

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Members of the Sounding Operational Algorithm Team (SOAT)

Barnet, Chris	NESDIS/STAR		Mooney, Dan	MIT-LL
Bingham, Gail	SDL		Revercomb, Hank	SSEC
Blackwell, Bill	MIT-LL		Smith, Bill	Hampton, Univ.
Derber, John	NESDIS/NCEP		Strow, Larrabee	UMBC
Goldberg, Mitch	NESDIS/STAR		Susskind, Joel	GSFC
Larar, Allen	LaRC		Swadley, Steve	NRL
Xu, Lu	LaRC		Tobin, Dave	SSEC
Menzel, Paul	SSEC		Yoe, Jim	NOAA/OSDPD